

## CLAIMS

What is claimed is:

1. In a communications system employing a plurality of rate matching stages, a method of avoiding problematic Turbo code puncturing patterns, the method comprising:

(a) adjusting the number of bits punctured in each stage of rate matching; and  
 (b) adjusting the number of bits punctured in each of the plurality of parity streams, wherein the problematic puncturing patterns are avoided.

2. The method of claim 1 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, and step (b) further comprises:

(b1) adding punctured bits to the first group of P1 bits;  
 (b2) removing punctured bits from the second group of P2 bits; and  
 (b3) biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns by:  
 (i) adding a number of non-punctured P1 bits to the first group; and  
 (ii) decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

3. The method of claim 2 further comprising:

(c) determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein  $I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching; and

(d) if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ , calculate the bias

$$\Delta = \left\lceil \max \left\{ \left\lfloor \frac{I}{\frac{7\hat{N}-1}{2}} \right\rfloor - \frac{P}{2}, \frac{P}{2} - \left\lfloor \frac{I}{\frac{7\hat{N}+1}{2}} \right\rfloor \right\} \right\rceil, \text{ otherwise set } \Delta = 0.$$

4. The method of claim 3, wherein non-puncturing patterns with a period of  $7\hat{N}/2$  cause degradation in performance results and  $\hat{N}$  is a whole number.

5. The method of claim 4 wherein the periods will be employed whenever the average non-puncturing period of P1 or P2 bits is within  $\pm 1$  or  $\pm 1/2$  of  $7\hat{N}/2$  for even and odd  $\hat{N}$  respectively.

6. In a communications system employing a plurality of rate matching stages, a method of avoiding problematic Turbo code puncturing patterns, the method comprising:

- (a) adjusting the number of bits punctured in each stage of rate matching; and
- (b) adjusting the puncturing rates of each of the individual parity streams while maintaining a constant overall effective coding rate.

7. The method of claim 6 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, and step (b) further comprises:

- (b1) adding punctured bits to the first group of P1 bits;
- (b2) removing punctured bits from the second group of P2 bits; and
- (b3) biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns by:
  - (i) adding a number of non-punctured P1 bits to the first group; and
  - (ii) decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

8. The method of claim 7 further comprising:

(c) determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein  $I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching; and

(d) if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ , calculate the bias

$$\Delta = \left\lfloor \max \left\{ \left\lfloor \frac{I}{\frac{7\hat{N}-1}{2}} - \frac{P}{2} \right\rfloor, \frac{P}{2} - \left\lfloor \frac{I}{\frac{7\hat{N}+1}{2}} \right\rfloor \right\} \right\rfloor, \text{ otherwise set } \Delta = 0.$$

9. The method of claim 8, wherein non-puncturing patterns with a period of  $7\hat{N}/2$  cause degradation in performance results and  $\hat{N}$  is a whole number.

10. The method of claim 9 wherein the periods will be employed whenever the average non-puncturing period of P1 or P2 bits is within  $\pm 1$  or  $\pm 1/2$  of  $7\hat{N}/2$  for even and odd  $\hat{N}$  respectively.

11. A method of identifying degradations in quality of punctured error correction coded transmissions, the method comprising:

(a) identifying a puncturing pattern which approximates a particular code rate; and

(b) adjusting a value for anticipated degradation in accordance with the matching of the puncturing pattern and the particular code rate.

12. The method of claim 11 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, and step (b) further comprises:

- (b1) adding punctured bits to the first group of P1 bits;
- (b2) removing punctured bits from the second group of P2 bits; and
- (b3) biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns by:
  - (i) adding a number of non-punctured P1 bits to the first group; and
  - (ii) decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

13. The method of claim 12 further comprising:

- (c) determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein  $I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching; and

- (d) if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ , calculate the bias

$$\Delta = \left\lceil \max \left\{ \frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2}, \frac{P}{2} - \frac{I}{\left\lfloor \frac{7\hat{N}+1}{2} \right\rfloor} \right\} \right\rceil, \text{ otherwise set } \Delta = 0.$$

14. The method of claim 11 further comprising:

- (c) using Turbo code to implement the error correction coded transmissions.

15. The method of claim 14 further comprising:

(d) identifying when a non-punctured bit pattern of the transmissions exhibits a periodic characteristic, with a period equal to a period of a semi-periodic impulse response of recursive encoding blocks of the Turbo code; and

(e) using the identified non-punctured bit patterns which exhibit a periodic characteristic to identify puncturing patterns with degraded performance.

16. A method of identifying degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits, the method comprising:

(a) adding punctured bits to the first group of P1 bits;

(b) removing punctured bits from the second group of P2 bits; and

(c) biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns by:

(i) adding a number of non-punctured P1 bits to the first group; and

(ii) decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

17. The method of claim 16 further comprising:

(d) using Turbo code to implement the error correction coded transmissions.

18. The method of claim 17 further comprising:

(e) identifying when a non-punctured bit pattern of the transmissions exhibits a periodic characteristic, with a period equal to a period of a semi-periodic impulse response of recursive encoding blocks of the Turbo code; and

(f) using the identified non-punctured bit patterns which exhibit a periodic characteristic to identify puncturing patterns with degraded performance.

19. A method for reducing degradations in quality of punctured error corrected code transmissions, the method comprising:

(a) identifying a puncturing pattern which approximates a particular code rate; and

(b) adjusting the parameters of the transmissions sufficiently to cause a mismatch in the puncturing pattern and the particular code rate.

20. The method of claim 19 further comprising:

(c) determining a capacity of a wireless transmit and receive unit (WTRU), including buffer sizes that are supported by the WTRU;

(d) using puncturing to remove sufficient bits to fit into the buffer; and

(e) adjusting an overall code rate so as to provide sufficient error correction capability, thereby providing a first rate in a first stage of puncturing and providing a second rate in a second stage of puncturing.

21. The method of claim 20, further comprising:

(f) increasing non-punctured bits in one of the first stage and second stage of puncturing, and decreasing non-punctured bits in another of the first stage and second stage of puncturing, thereby adding additional puncturing to one stage and removing it from the other stage.

22. The method of claim 20 further comprising:

(f) increasing non-punctured bits in the first stage and decreasing non-punctured bits in the second stage.

23. The method of claim 20 further comprising:

(f) decreasing non-punctured bits in the first stage and increasing non-punctured bits in the second stage.

24. The method of claim 20 further comprising:

(f) interleaving parity bits before rate matching occurs; and

(g) subsequently de-interleaving the parity bits, thereby avoiding a need to periodically sample the parity bits when performing periodic sampling in rate matching, thereby mitigating the effect of the periodicity of the puncturing pattern.

25. A communications system for avoiding problematic Turbo code puncturing patterns, the system comprising:

(a) a plurality of rate matching stages;

(b) means for adjusting the number of bits punctured in each stage of rate matching; and

(c) means for adjusting the number of bits punctured in each of the plurality of parity streams, wherein the problematic puncturing patterns are avoided.

26. The system of claim 25 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, the means (c) for adjusting the number of bits punctured in each of the plurality of parity streams further comprising:

(c1) means for adding punctured bits to the first group of P1 bits;

(c2) means for removing punctured bits from the second group of P2 bits;

and

(c3) means for biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns, the biasing means including:

(i) means for adding a number of non-punctured P1 bits to the first group;

and

(ii) means for decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

27. The system of claim 26 further comprising:

(d) means for determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein  $I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching; and

(e) means for calculating the bias  $\Delta = \left\lceil \max \left\{ \left\lfloor \frac{I}{\frac{7\hat{N}-1}{2}} - \frac{P}{2}, \frac{P}{2} - \left\lfloor \frac{I}{\frac{7\hat{N}+1}{2}} \right\rfloor \right\} \right\rceil$  if

$$\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor; \text{ and}$$

(e) means for setting bias  $\Delta = 0$  if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| \geq 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ .

28. The system of claim 27, wherein non-puncturing patterns with a period of  $7\hat{N}/2$  cause degradation in performance results and  $\hat{N}$  is a whole number.

29. The system of claim 28 wherein the periods will be employed whenever the average non-puncturing period of P1 or P2 bits is within  $\pm 1$  or  $\pm 1/2$  of  $7\hat{N}/2$  for even and odd  $\hat{N}$  respectively.

30. A communications system for avoiding problematic Turbo code puncturing patterns, the system comprising:

- (a) a plurality of rate matching stages;
- (b) means for adjusting the number of bits punctured in each stage of rate matching; and
- (c) means for adjusting the puncturing rates of each of the individual parity

streams while maintaining a constant overall effective coding rate.

31. The system of claim 30 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, the means (c) for adjusting the puncturing rates of each of the individual parity streams further comprising:

(c1) means for adding punctured bits to the first group of P1 bits;

(c2) means for removing punctured bits from the second group of P2 bits;

and

(c3) means for biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns, the biasing means (c3) including:

(i) means for adding a number of non-punctured P1 bits to the first group;

and

(ii) means for decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

32. The system of claim 31 further comprising:

(d) means for determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein

$I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching;

(e) means for calculating the bias  $\Delta = \left\lceil \max \left\{ \frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2}, \frac{P}{2} - \frac{I}{\left\lfloor \frac{7\hat{N}+1}{2} \right\rfloor} \right\} \right\rceil$  if

$\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ ; and

(e) means for setting bias  $\Delta = 0$  if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| \geq 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ .

33. The system of claim 32, wherein non-puncturing patterns with a period of  $7\hat{N}/2$  cause degradation in performance results and  $\hat{N}$  is a whole number.

34. The system of claim 33 wherein the periods will be employed whenever the average non-puncturing period of P1 or P2 bits is within  $\pm 1$  or  $\pm 1/2$  of  $7\hat{N}/2$  for even and odd  $\hat{N}$  respectively.

35. A communications system for identifying degradations in quality of punctured error correction coded transmissions, the system comprising:

(a) means for identifying a puncturing pattern which approximates a particular code rate; and

(b) means for adjusting a value for anticipated degradation in accordance with the matching of the puncturing pattern and the particular code rate.

36. The system of claim 35 wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, the means (b) for adjusting a value for anticipated degradation further comprising:

(b1) means for adding punctured bits to the first group of P1 bits;

(b2) means for removing punctured bits from the second group of P2 bits;

and

(b3) means for biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns, the biasing means (b3) including:

(i) means for adding a number of non-punctured P1 bits to the first group;

and

(ii) means for decreasing the number of non-punctured P2 bits in the

second group by the number of non-punctured P1 bits added to the first group.

37. The system of claim 36 further comprising:

(c) means for determining a number of bits  $\hat{N}$  using  $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$  wherein

$I$  is the number of bits at the input to each branch of rate matching and  $P$  is the total number of the P1 and P2 bits at the output of rate matching;

(d) means for calculating the bias  $\Delta = \left\lceil \max \left\{ \left\lfloor \frac{I}{\frac{7\hat{N}-1}{2}} - \frac{P}{2} \right\rfloor, \frac{P}{2} - \left\lfloor \frac{I}{\frac{7\hat{N}+1}{2}} \right\rfloor \right\} \right\rceil$  if

$$\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor; \text{ and}$$

(e) means for setting bias  $\Delta = 0$  if  $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| \geq 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$ .

38. The system of claim 35 further comprising:

(c) means for using Turbo code to implement the error correction coded transmissions.

39. The system of claim 38 further comprising:

(d) means for identifying when a non-punctured bit pattern of the transmissions exhibits a periodic characteristic, with a period equal to a period of a semi-periodic impulse response of recursive encoding blocks of the Turbo code; and

(e) means for using the identified non-punctured bit patterns which exhibit a periodic characteristic to identify puncturing patterns with degraded

performance.

40. A communications system for identifying degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits, the system comprising:

(a) means for adding punctured bits to the first group of P1 bits;

(b) means for removing punctured bits from the second group of P2 bits;

and

(c) means for biasing the punctured rates of the P1 and P2 bits to avoid problematic puncturing patterns, the biasing means (c) including:

(i) means for adding a number of non-punctured P1 bits to the first group;

and

(ii) means for decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group.

41. The system of claim 40 further comprising:

(d) means for using Turbo code to implement the error correction coded transmissions.

42. The system of claim 41 further comprising:

(e) means for identifying when a non-punctured bit pattern of the transmissions exhibits a periodic characteristic, with a period equal to a period of a semi-periodic impulse response of recursive encoding blocks of the Turbo code; and

(f) means for using the identified non-punctured bit patterns which exhibit a periodic characteristic to identify puncturing patterns with degraded performance.

43. A communications system for reducing degradations in quality of punctured error corrected code transmissions, the system comprising:

(a) means for identifying a puncturing pattern which approximates a particular code rate; and

(b) means for adjusting the parameters of the transmissions sufficiently to cause a mismatch in the puncturing pattern and the particular code rate.

44. The system of claim 43 further comprising:

(c) means for determining a capacity of a wireless transmit and receive unit (WTRU), including buffer sizes that are supported by the WTRU;

(d) means for using puncturing to remove sufficient bits to fit into the buffer; and

(e) means for adjusting an overall code rate so as to provide sufficient error correction capability, thereby providing a first rate in a first stage of puncturing and providing a second rate in a second stage of puncturing.

45. The system of claim 44, further comprising:

(f) means for increasing non-punctured bits in one of the first stage and second stage of puncturing, and decreasing non-punctured bits in another of the first stage and second stage of puncturing, thereby adding additional puncturing to one stage and removing it from the other stage.

46. The system of claim 44 further comprising:

(f) means for increasing non-punctured bits in the first stage and decreasing non-punctured bits in the second stage.

47. The system of claim 44 further comprising:

(f) means for decreasing non-punctured bits in the first stage and increasing non-punctured bits in the second stage.

48. The system of claim 44 further comprising:

(f) means for interleaving parity bits before rate matching occurs; and

(g) means for subsequently de-interleaving the parity bits, thereby avoiding a need to periodically sample the parity bits when performing periodic sampling in rate matching, thereby mitigating the effect of the periodicity of the puncturing pattern.